

Wavelength Shifting Light Collector Plates

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Outline

- i) Wavelength shifting plates for LBNE water Cerenkov detector
- ii) Potential design modifications and improvements to the plates
- iii) Water Cerenkov facility developed at Colorado State University

Prototypes

BC 499-76

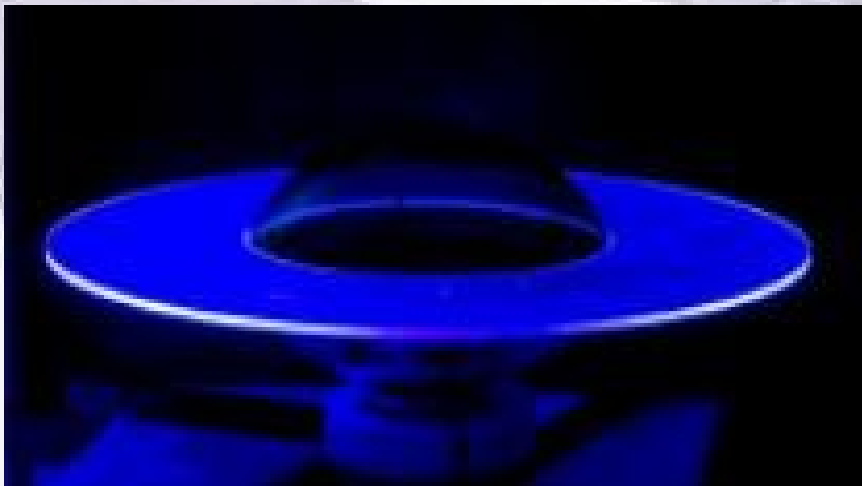
Absorbs UV 260nm-400nm

Emits 435nm

Fluorescence decay time 2.1ns

Hard to fully test with LEDs

Absorption and emission well suited to water Cerenkov and PMTs



BC 482a

Absorbs 370nm-470nm

Emits green

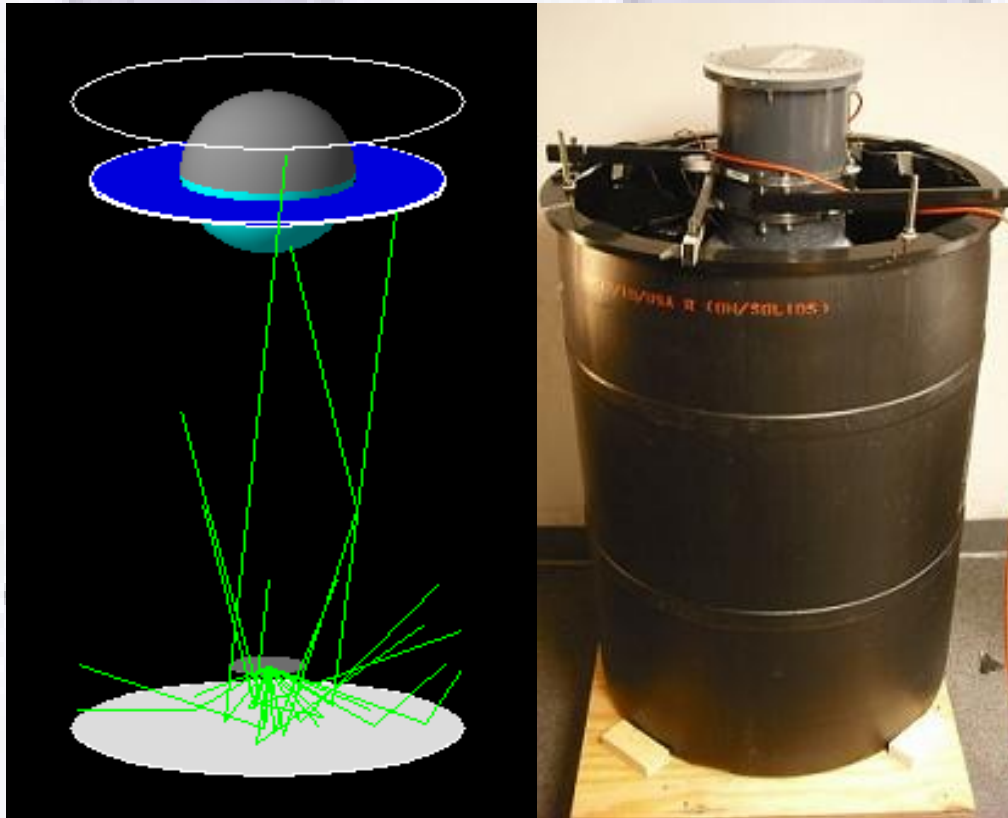
Fluorescence decay time 12ns

Easily tested with LEDs

Absorption and emission not well suited to water Cerenkov



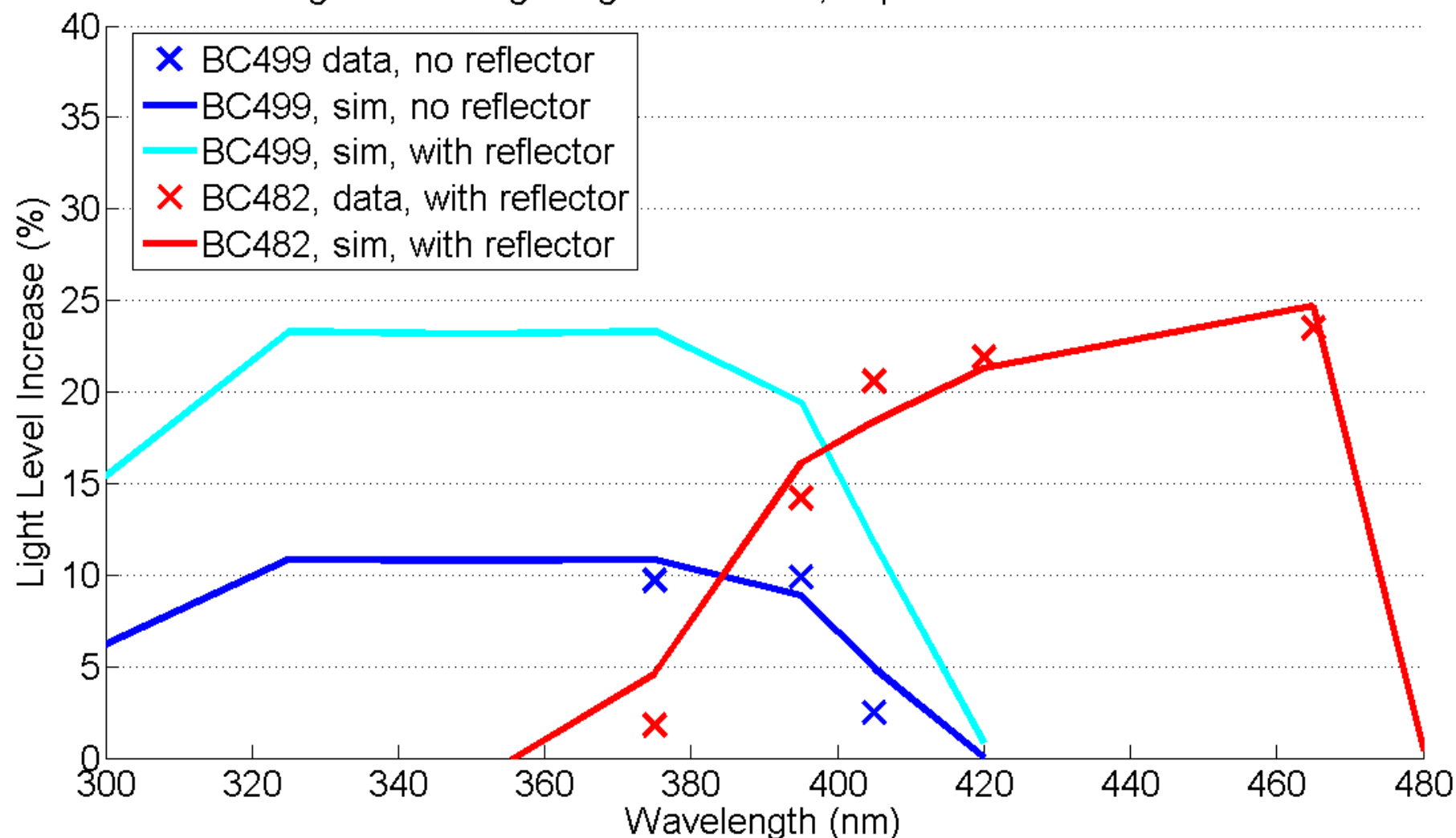
Testing Drum Setup



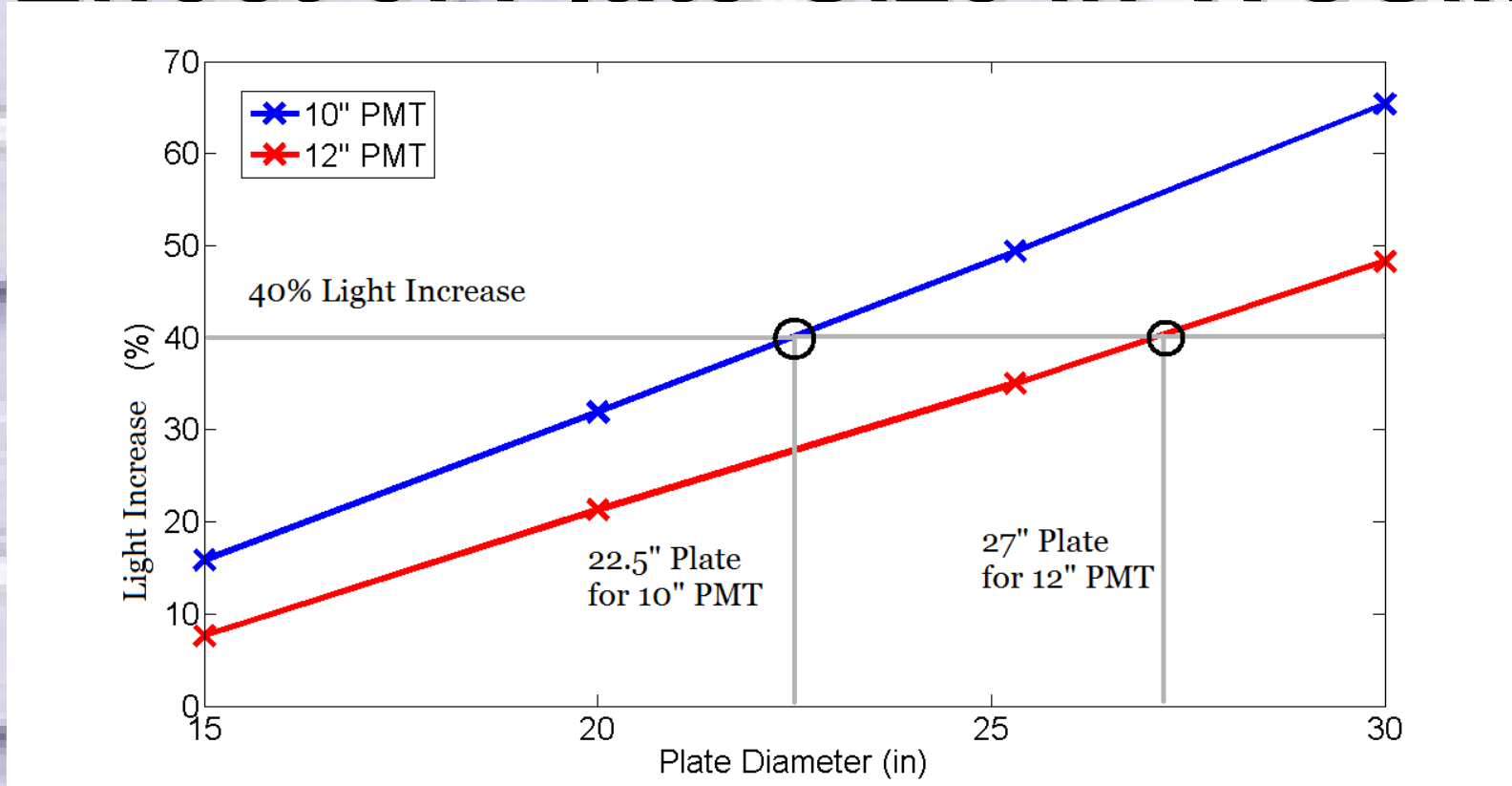
- LED photons injected into bottom of drum through optical fiber
- Light is diffused by two Tyvek surfaces for uniform distribution
- PMT sits at top of drum facing down
- PMT can be tested at several wavelengths, with and without light collectors in a single day

Testing Drum Results

Single Wavelength Light Collection, Experiment and Simulation



Effect of Plate Size in WCSim



Light reaching PMT increases linearly with plate size

Same behavior seen in IMB tests on square light collectors

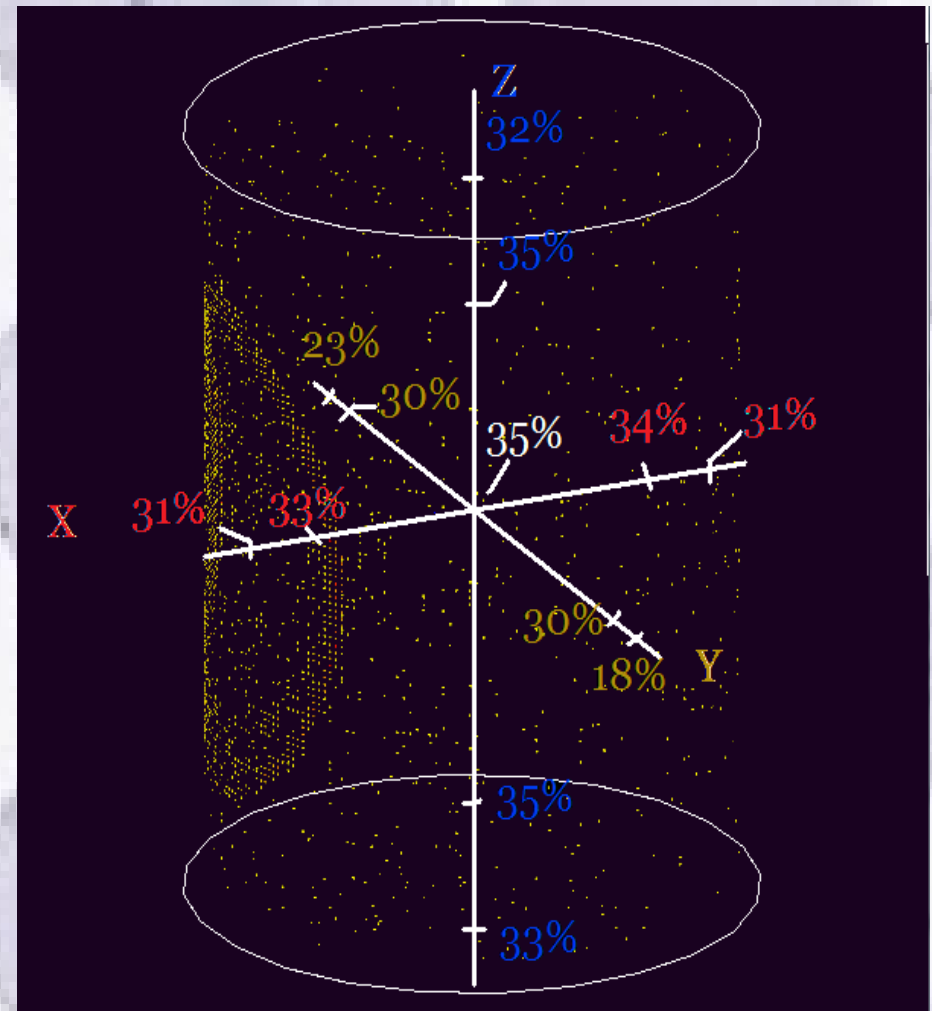
Variation of Plate Efficiency with Vertex Location

- 1GeV muons were shot into the tank from various vertex locations

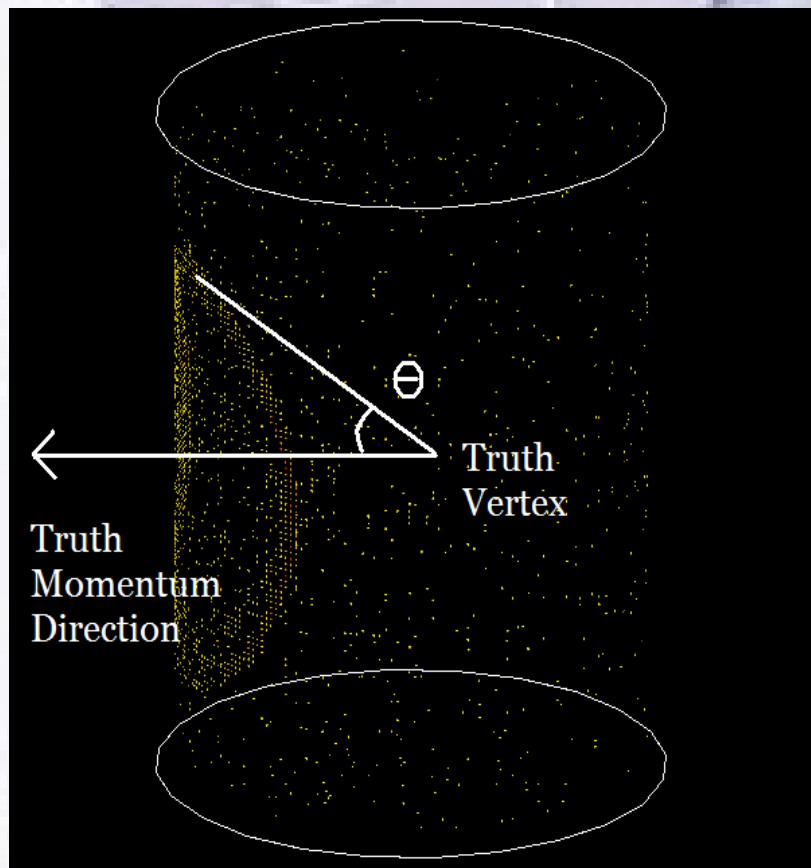
Momentum always in x-direction

- Increase in light level shows some position dependence when track is near wall and parallel to it

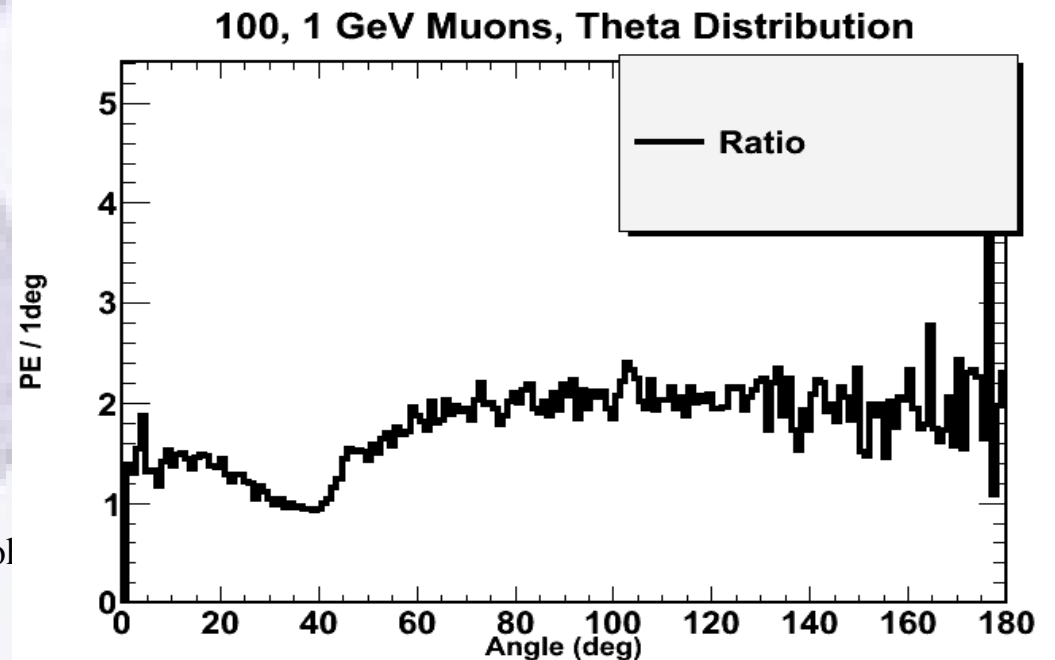
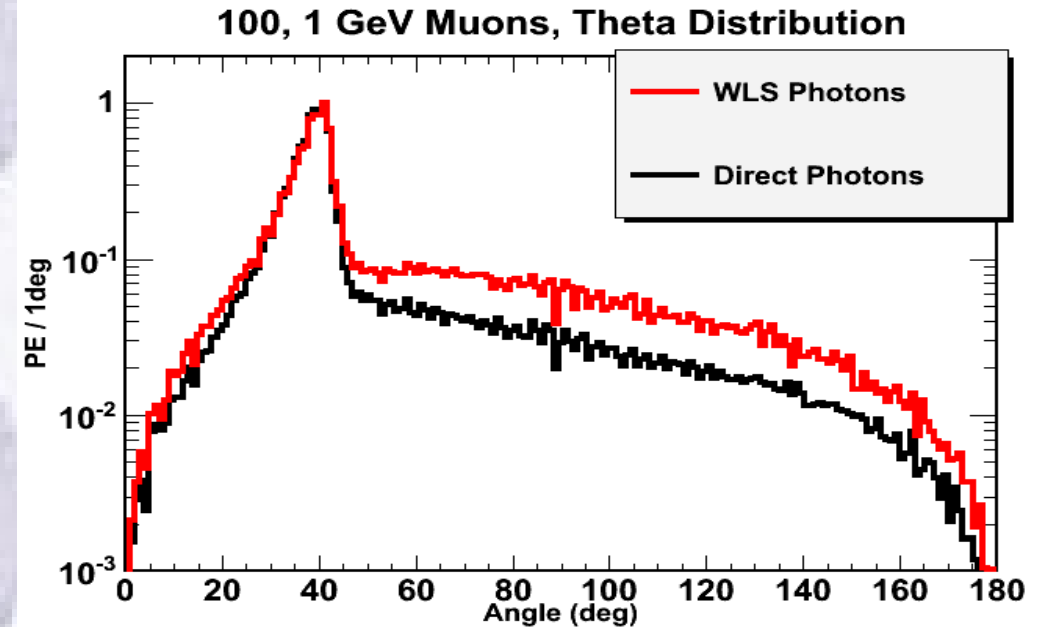
The light level has increased fairly uniformly over a large volume of the tank



Effect of Plates on Cerenkov Rings

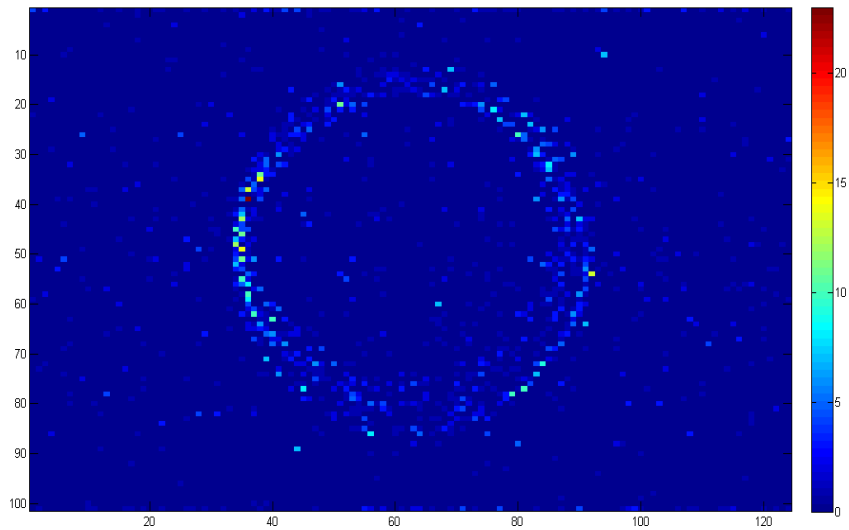


➔ Maximum bin of each distribution scaled to 1

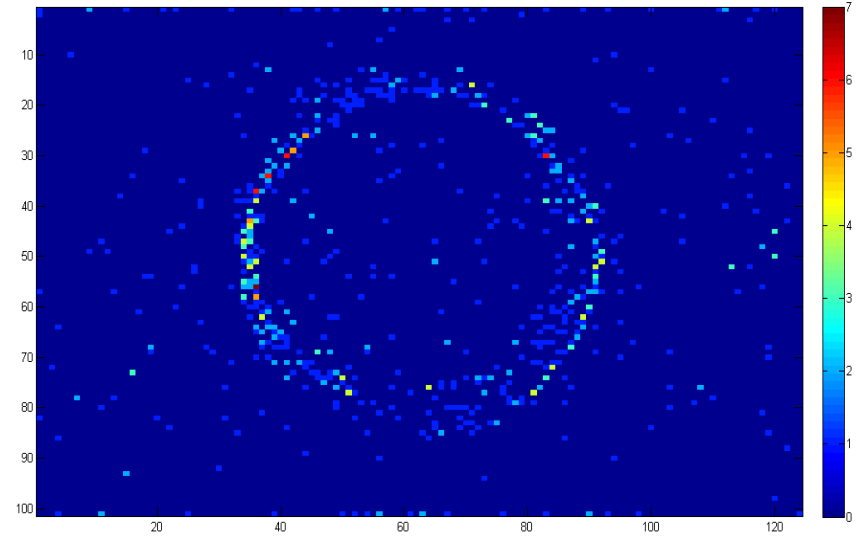


Effect of Plates on 1GeV Ring

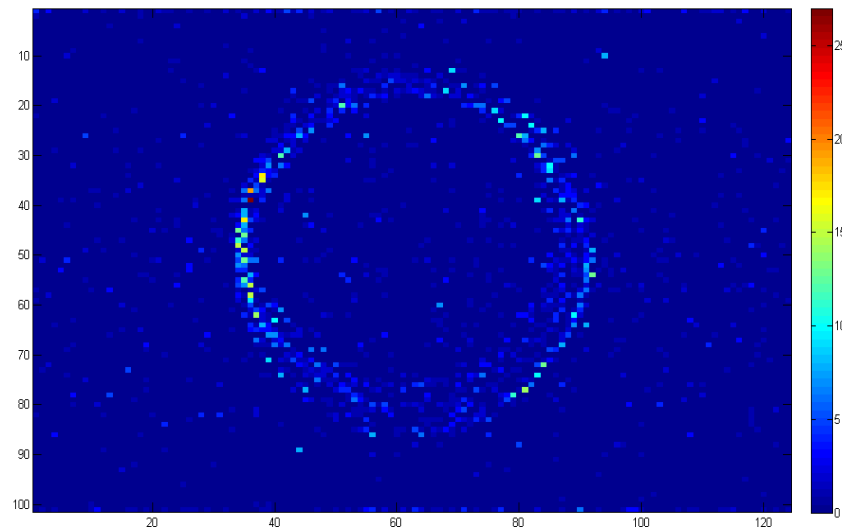
Direct Photons, 1GeV Muon



WLS Photons, 1GeV Muon



All Photons, 1GeV Muon

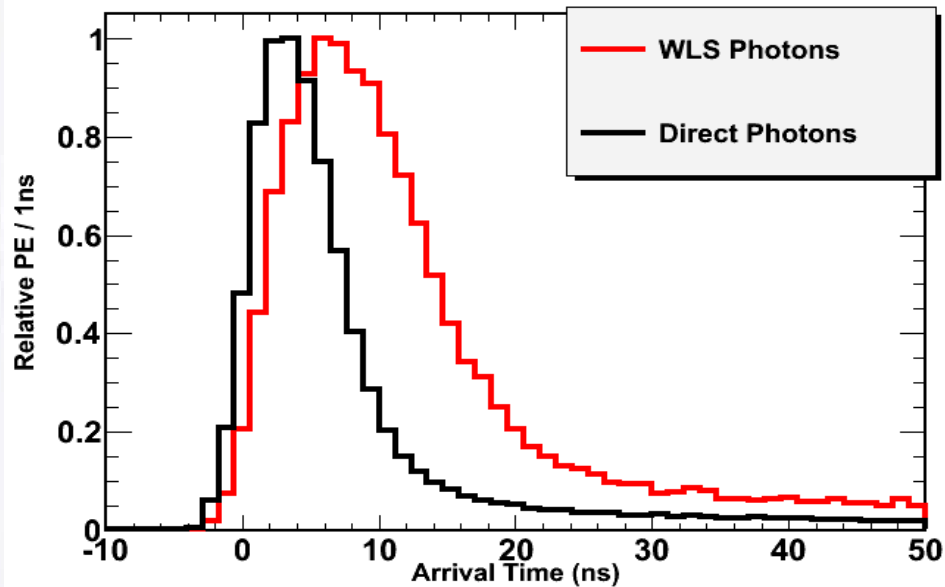


October 10, 2011

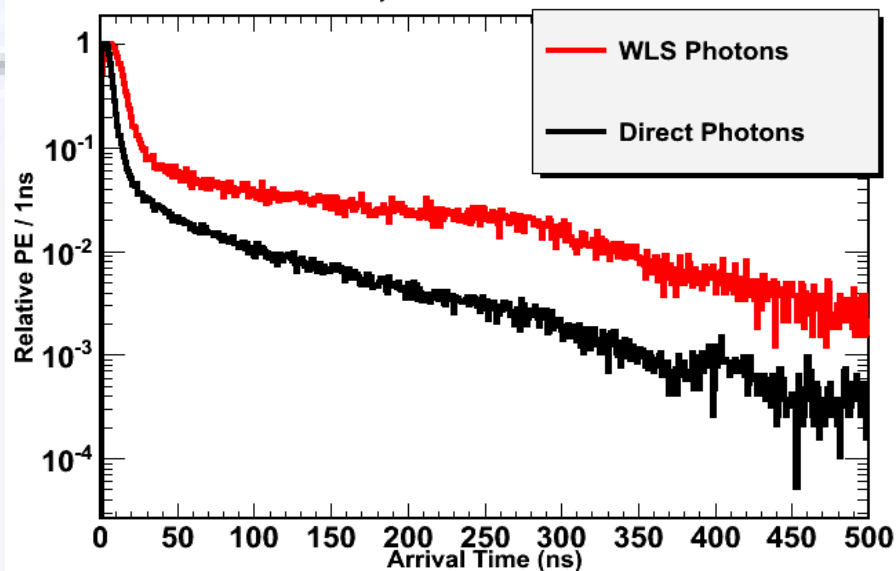
Timing

- WLS timing affected by fluorescence decay time, propagation time through plastic, and re-emitted light
- Two plots at left have had the WLS and direct photons separated and scaled for easy comparison
- Bottom right plot shows the overall effect of plates for 200 kton detectors with different photocathode coverages

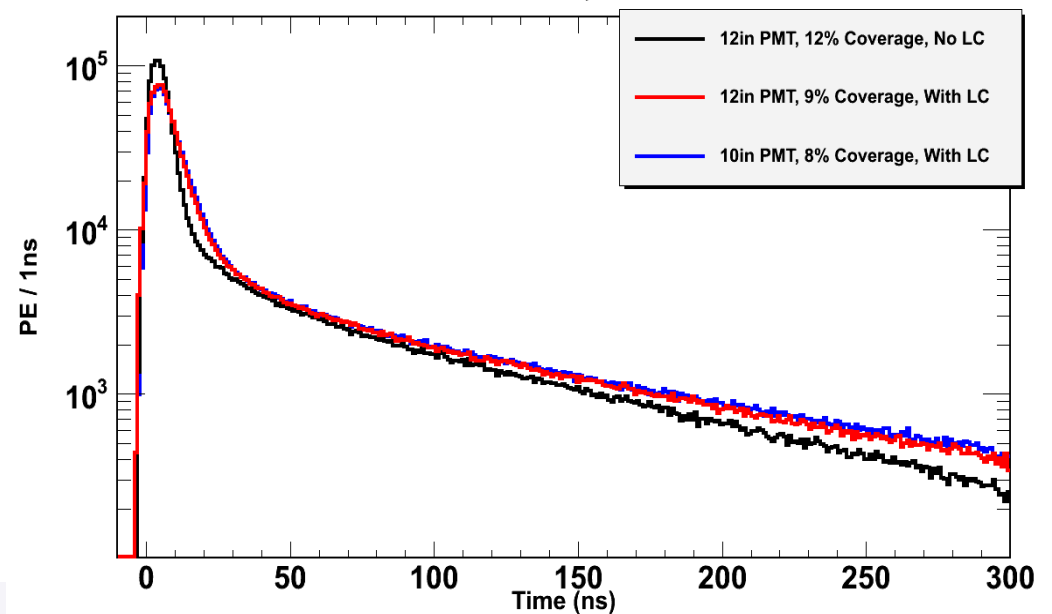
100, 1 GeV Muons



100, 1 GeV Muons



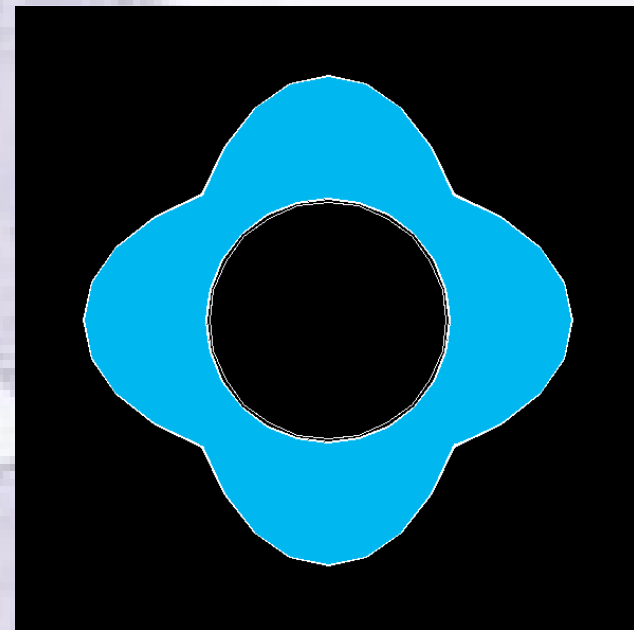
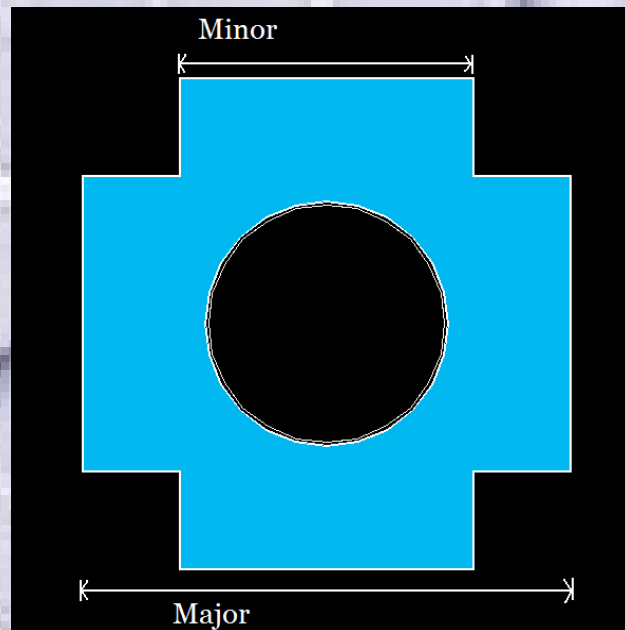
500 MeV Electron, Center of Tank



Modifications and Improvements to the WLS Plate

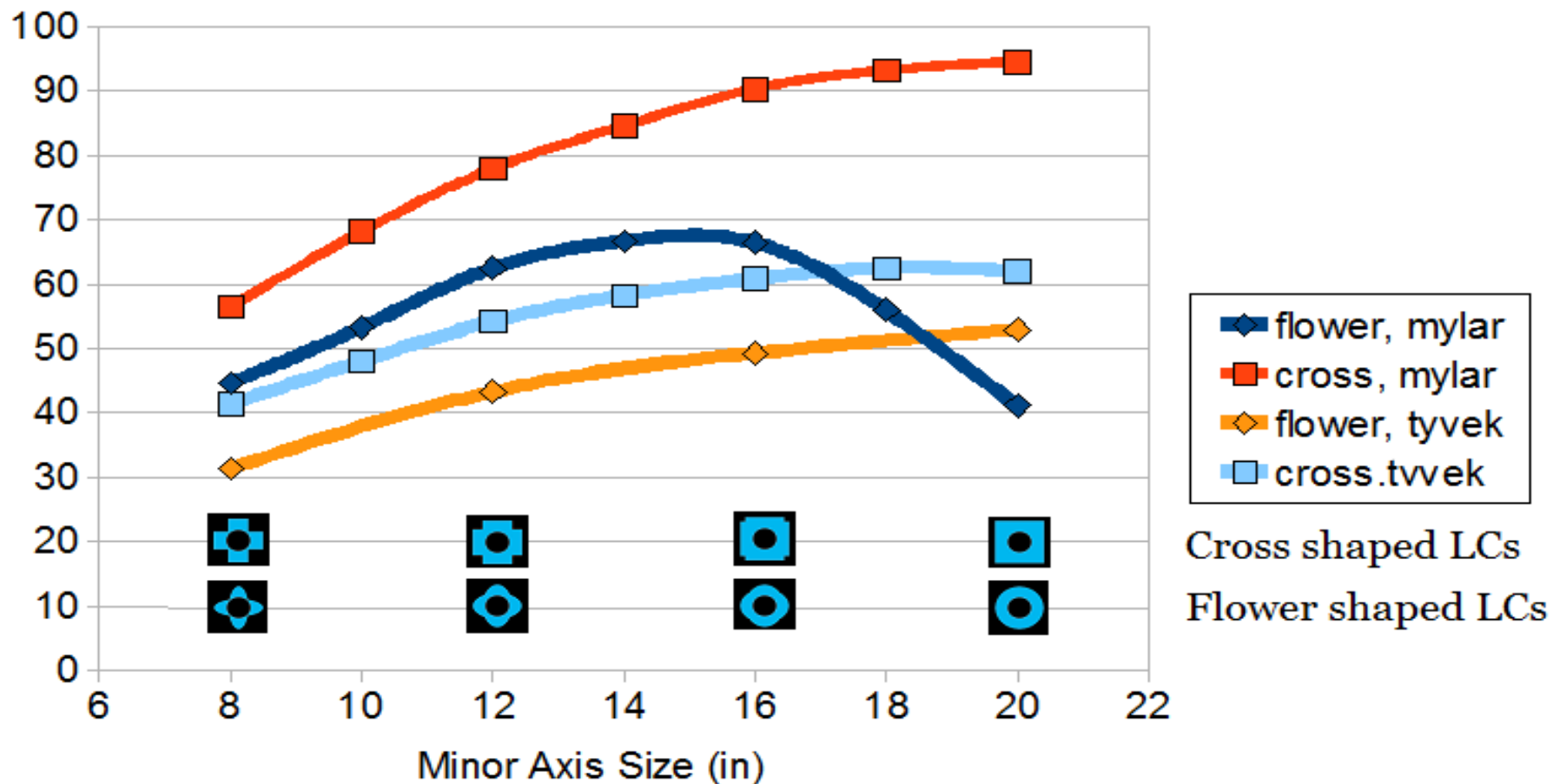
- Basic circular light collector is currently our proposed design for LBNE
- Looking at ways to improve performance of plates
 - 1) Different plate geometries
 - 2) Use of a filter to reduce the light re-emitted into the tank

Plate Geometries



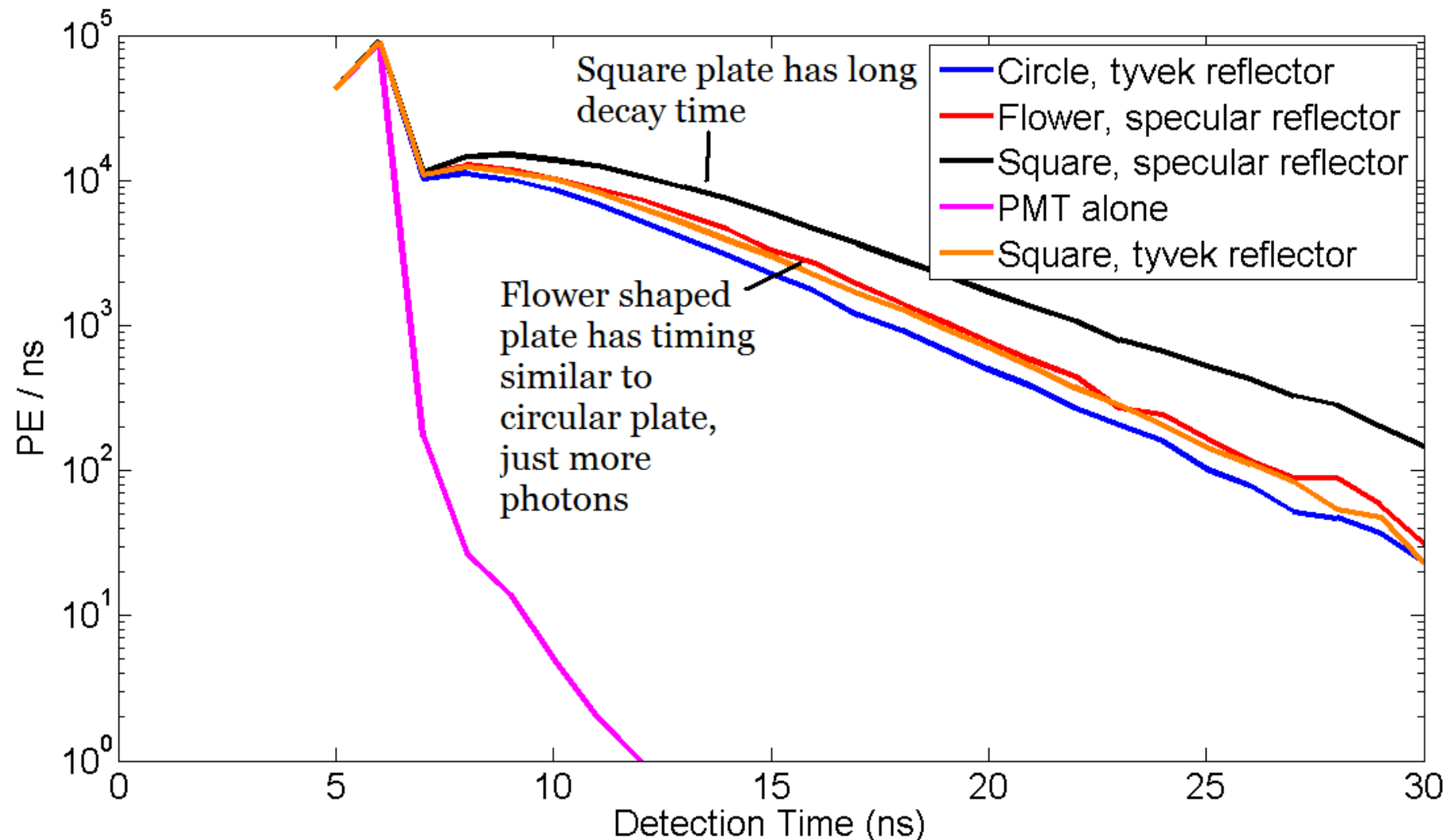
- Increase light collection by guiding photons off outer edge towards the PMT
 - Requires a specular edge reflector
- Flower shaped LC is made by combining two ellipses that are rotated 90° to each other
- Plates can be cast to desired shape, shouldn't be harder to produce than a circle
- Also tried variable thickness circular plates, reduced the light collection by a few percent

Effect of Plate Geometry on Efficiency

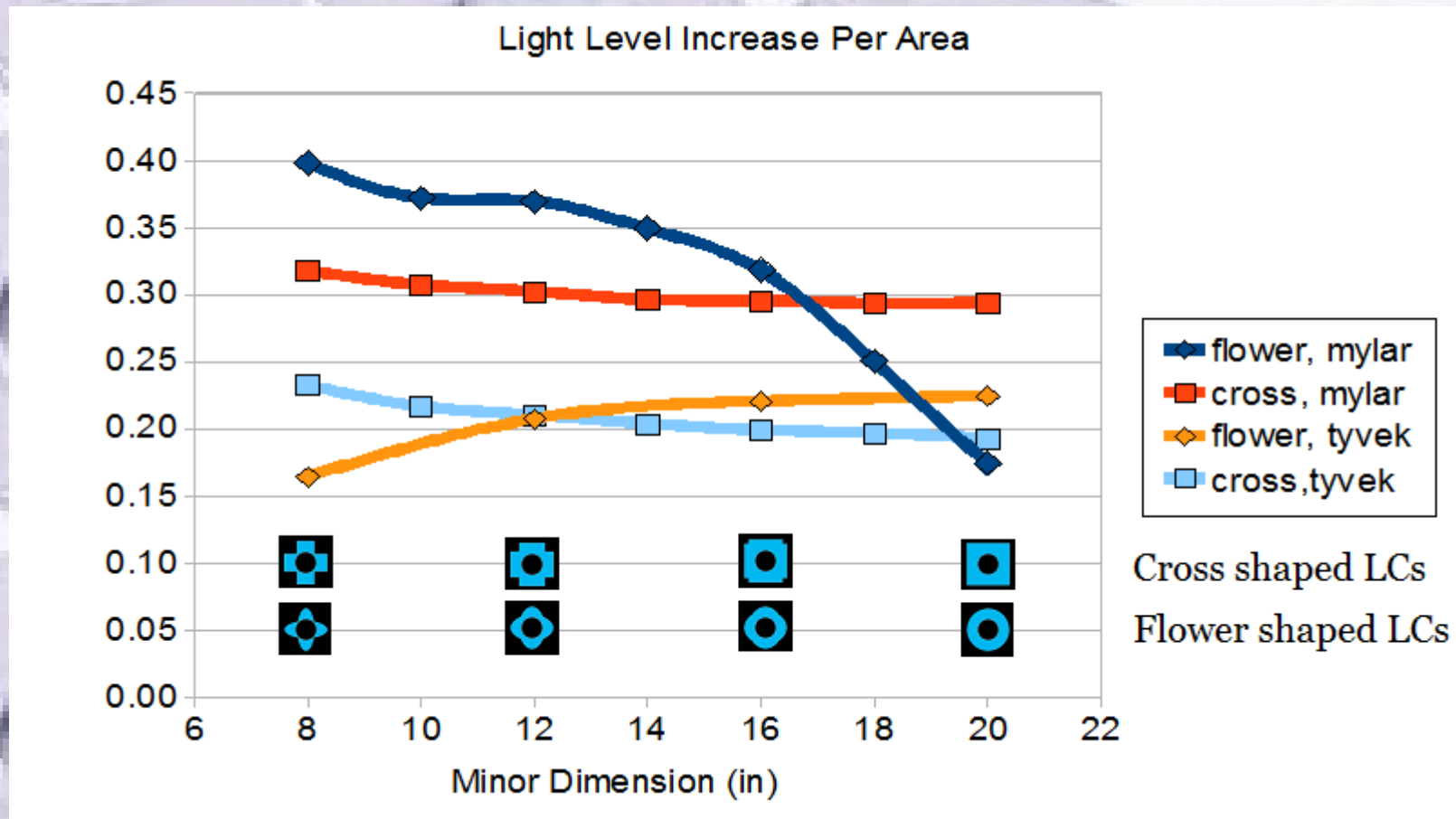


→ All plates 20" wide on 10" PMT

Timing of Different Plate Geometries



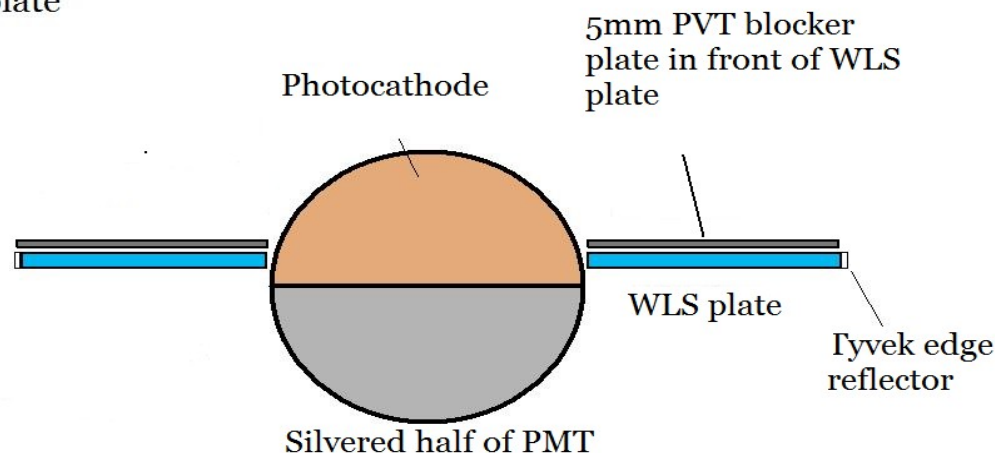
Light Collection per Area



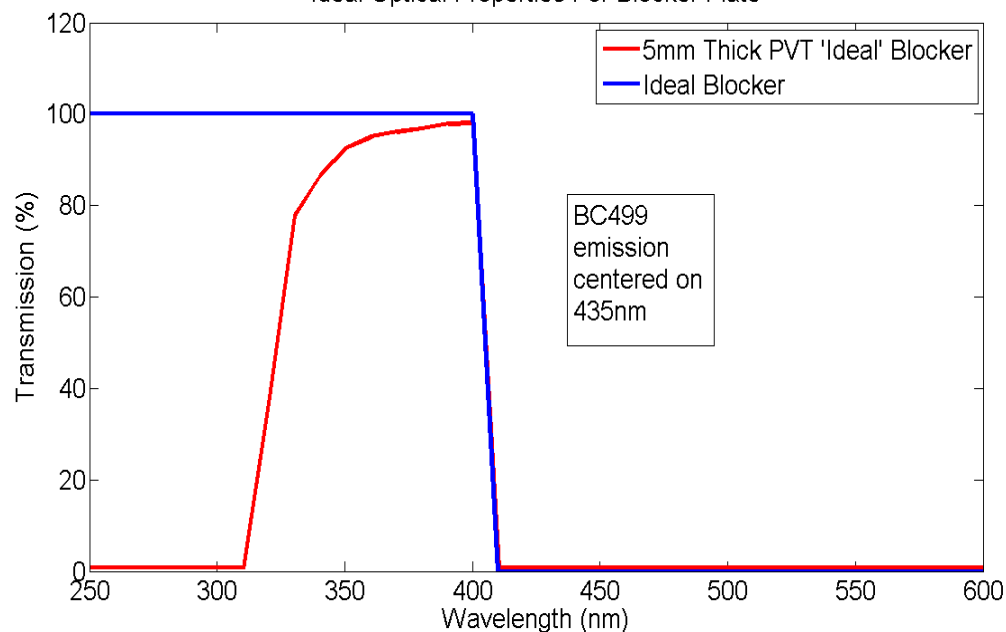
- Higher numbers mean less re-emitted light for each photon detected by PMT
- Higher numbers also mean less cost per collected photon

Crosstalk Filter Plate

Side view of PMT with WLS plate



Ideal Optical Properties For Blocker Plate



- Wavelength shifted light is UV but the light emitted is blue
 - A sheet of plastic that is opaque to blue light but transparent to UV can be used to block re-emitted light
- Not sure if anything like this ideal plastic filter exists
 - Small glass filters exist but are expensive
- Tested a PVT based filter in WCSim
 - Efficiency of WLS plate reduced ~10%
 - Re-emitted light reduced by ~50%
 - Need more time to look over data to see how promising this idea is

Current Conclusions About Modifications to Basic WLS Plate

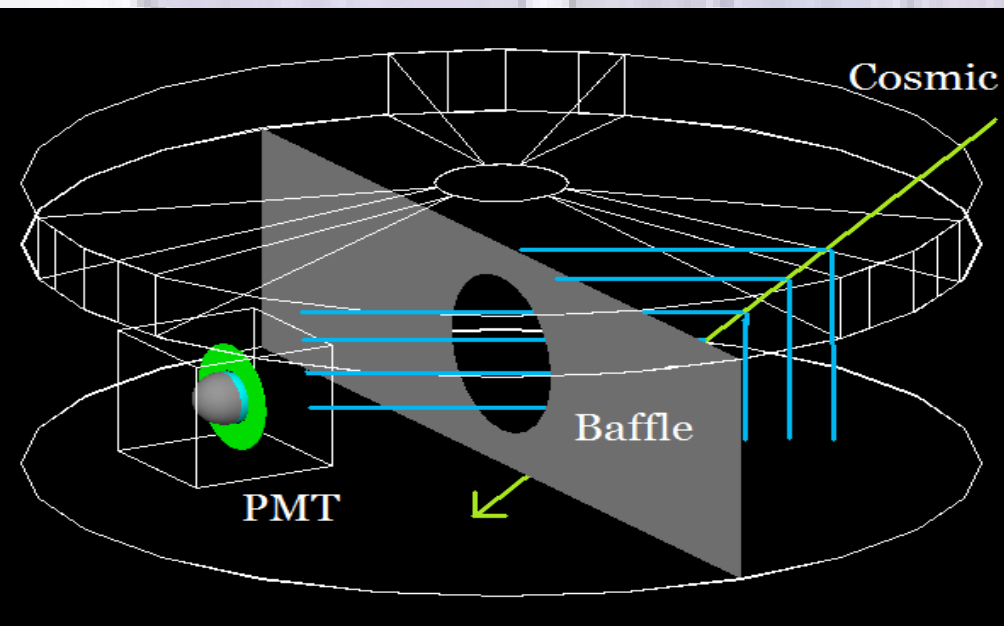
- More work will be done on determining the best shape for the plate's outer edge
 - Big (50%) improvements in light collection with no change in timing already seen
 - Large potential for reducing the size of plate while preserving light collection
- Crosstalk filter plate shows promise but would require a large time investment to find suitable materials
 - Will keep an eye out for useful plastics

Water Cerenkov Facility



- 10 ton, light-tight water tank
- 12 foot diameter
- Water is 4 feet deep
- 22" diameter access port
- Filter system with UV sterilization system
- VME readout system

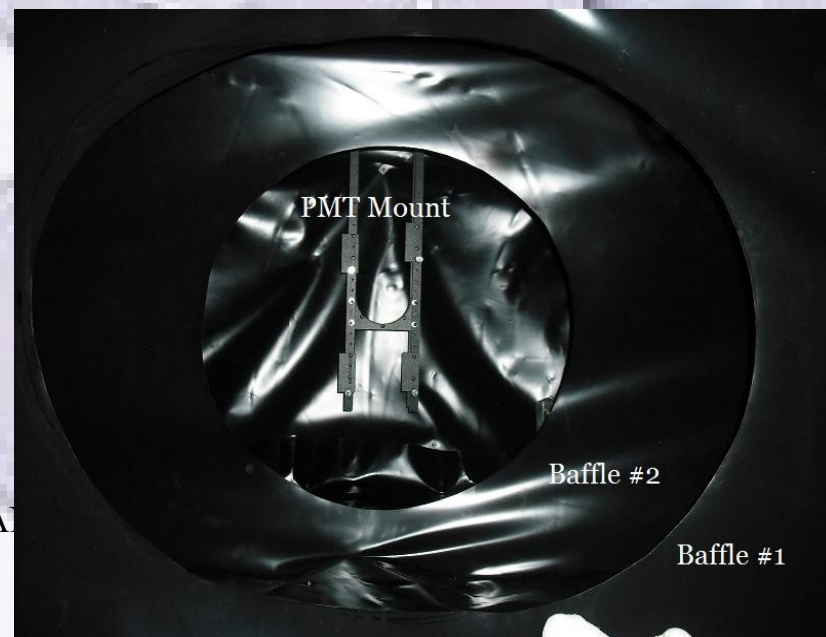
Tank Layout



- In-house Geant4 simulation used to determine internal layout
- Baffle and trigger layout produces collimated Cerenkov light at the PMT

Light reaching PMT is traveling parallel to the bottom of the tank

- Tank has two baffles, second one doesn't render well due to its shape
- PMT mount can rotate to study effect of incidence angle

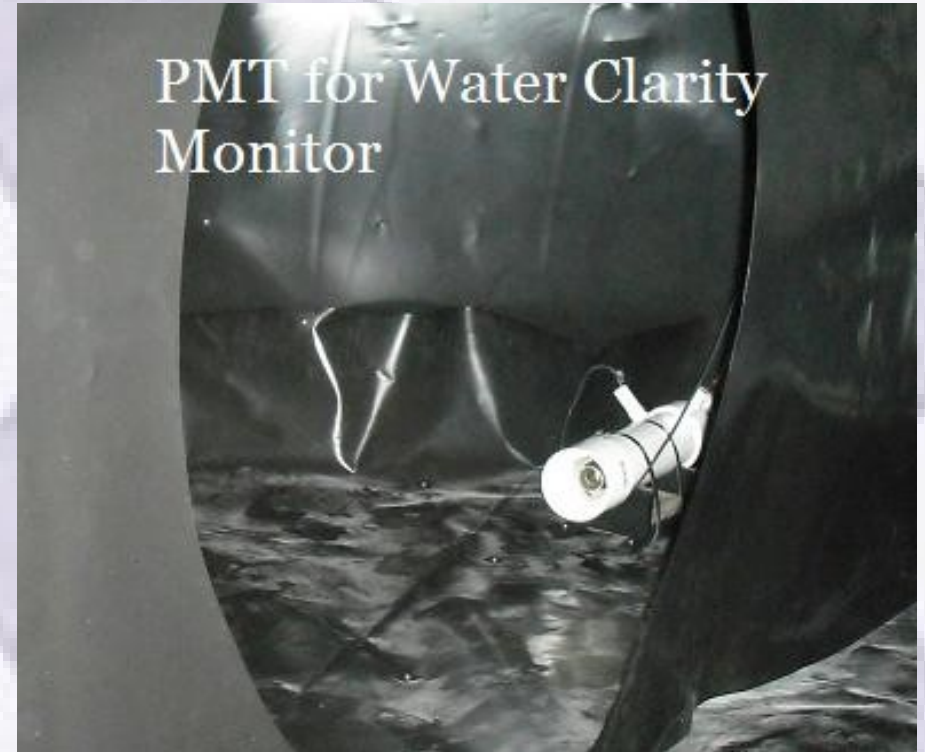


Water Clarity Monitor

- 2" flat faced PMT mounted to bottom of tank
- Fiber mounted 10 feet away injects light from a UV LED

Additional PMT
outside of tank
measures LED output

- Fiber and monitor PMT are placed behind baffle, away from the test PMT



Work to Be Done

- Preliminary measurements under Cerenkov light were made before lining tank with black plastic

Electronics and software are complete and have been tested

- Need to run the filters and water clarity system in order to understand the stability of the water's optical properties

This work resumes next week

- Once we are confident in the stability, testing will begin
- Test 2nd generation prototypes
- Absorption and emission spectroscopy is being done on our WLS plastic samples

Results will be in hand in any day

This new updated information will be entered into WCSim once it has been looked over